INSTITUTE OF MACHINE AND INDUSTRIAL DESIGN

FME

Faculty of Mechanical Engineering
Brno University of Technology

Review of Doctoral Thesis

1. PhD candidate
Ing. Matúš Ranuša / Matus.Ranusa@vut.cz
2. Name of PhD programme
Design and Process Engineering
3. Title of PhD thesis
Volumetric Wear Analysis of Hip Joint Implants by Optical Methods

4. Principal supervisor
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/

6. Reviewer
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7. Overview of the scope of PhD thesis[1]
Satisfactory
The thesis addresses a topic with a set of clear objectives that has the potential to infer some societal benefit. The theses aims can be split into two with the main aim of the thesis to develop a new method to assess the wear of PE implant materials. The second was to further expand this analysis and link the wear, degradation and time dependant processes. This is clearly stated. However the objectives, or steps as given in the thesis, to achieve the project aims are not well articulated and could be better articulated. These should be expanded upon to be specific, measurable, achievable, realistic and timely. By doing this, it would better demonstrate the candidates understanding of how the different analysis techniques contribute to understanding the multi-factorial degradation mechanisms.

8. Significance of the topic and clarity of problem statement
Good
Wear, and an understanding of the degradation mechanisms, of polymer components used in THR and other areas of orthopaedics is and continues to be a significant problem. The ability to effectively engineer surfaces and interfaces to reduce these processes would have a significant impact for patients and healthcare providers by reducing the need for future revision and longer lasting implant materials. The

[1] Overview of the scope of PhD thesis is a short description of objectives of PhD thesis's research and summary of main findings and scientific achievements.

problem that the thesis looks addresses, the accurate measurement of components, is a current and timely issues given the current scrutiny in the preclinical and surveillance of medical implants. The thesis effectively addresses these points and articulates the key drivers of this research.

9. Knowledge of existing literature

Satisfactory

The literature review presents a general overview of the current state of the art in the area of orthopaedics and PE wear. It covers all the expected topics with some critical assessment (mainly for the measurement methods) of the literature made. In places the literature review lacks clarity and accuracy in the writing. For example, this is particularly the case where measurement methods are been discussed for both in-vivo and in-vitro literature, but not stated. Furthermore a full critique of the pre-clinical literature and the associated assessment methods. For example, a brief literature review on hip simulation methods is presented. However this is limited to the discussion of one simple and now out of date approach. A discussion and critique of the literature pertaining to the current tribological principles of MoP articulations is not included and limited to a simple analysis of wear mechanisms. A thorough review of the current concepts of wear and lubrication of MoP THRs, and the associated literature, would be expected as one of the main aims is link the understand the links between wear and degradation of the polymer. An annotated copy of the thesis is available if required.

10. Choice of methods and technical soundness

Good

The thesis makes a good use of a combination of different methods to address the aims and objectives. The use of optical hi resolution optical metrology measurement methods to assess the wear of PE implant materials in its self is novel. The use of RAMAN, SEM and surface profilometry to resolve the local changes in material properties and topography further add to the novelty. The simulation methods used to generate wear are limited. However was not the focus of study in this thesis. One aspect that did not receive much consideration in the thesis was the consideration of the algorithm used to assess wear or the factors that may influence wear measurements. The accurate measurement of the surfaces is not technically challenging, as highlighted by the thesis. However the identification of work areas and fitting of data to well defined geometries is an area of significant challenge. For example, a thresholding process is applied with a value of 3um. A thorough analysis of this parameter is not presented or how this may be effect the overall wear measurement, particular in the case of the reference surfaces where there will be some manufacturing deviations. Furthermore the use of geometrically perfect fitting algorithms has a number of limitations. The algorithms for fitting data, both commercial and home code, have not been assessed or critiqued. It would have also benefitted from the use of CMM methods to compare and validate against. Details of the metrology methods are detailed. Details of the Raman, including preparation of samples (ie were the lipids removed?) and data fitting methods, nano-indentation and analysis of the data and SEM prep and imaging conditions is limited.

11. Quality, originality and significance of the results

Good

The quality and originality of the results are as expected from a PhD thesis and are in line with other literature. The methodology and framework developed is novel and the key strength of the thesis. In my opinion the thesis would have benefitted from a thorough analysis of the results and the algorithm used to assess the results to demonstrate the robustness of the measurement. Due to the small number of implants it is difficult to draw any conclusions on the mechanisms of wear from the retrieved components,

although the framework for high thru-put analysis is now in place. With respect to the hip simulator results, there are some comments and limitations of the measurements in the absence of static load control surfaces which would are needed for the deconvolution of creep and wear.

12. Quality of attached papers
Good
The papers attached are of good quality and published in recognised peer-reviewed journals in the area of tribology and biomaterials. The papers present data that addresses the main research aim. One comment is that it is still not made overly obvious how the results presented can be used for future implant designs or inform the current tribological models. For example, the oxidation paper shows differences between the OI or fresh and implanted materials. However the changes in properties are not obviously linked to the tribology or wear data. It is obvious that a methodology has been used to measure the wear and existing techniques has been used to assess degradation. How this contributes to a mechanistic understanding of the degradation is not obvious. There are also some issues with the use of friction data obtained in this study.

13. Overall assessment, strengths and weaknesses (based upon the above evaluation categories 8–12)
Good
Overall the thesis highlights and addresses a current issue in the preclinical and clinical evaluation of PE implant materials. It proposes a new framework for the assessment of wear of PE components and observations of degradation on a select number of implants. One limitation of the thesis is limited number of implants used or stratification of groups to enable a well-defined retrieval wear study to be completed. There is a nice attempt to de-convolute wear and creep processes in hip simulation. There are some issues with the simulator approach used, the numbers analysed and the appropriate use of controls, as highlighted above. The written thesis would benefit from a through proof read and critical evaluation to ensure consistency and accuracy (both grammatically and scientifically) of the content.

14. Other comments
An annotated copy of the thesis is available for review if required.

15. Conclusion
PhD thesis is an independent scientific work that presents a novel solution to a significant problem in the research area and demonstrates the candidate's ability to conduct independent research.
YES

16. Date and signature	
01/01/2019	

Please note

A. *Evaluate categories 7 to 13 using the following scale: unacceptable, acceptable, satisfactory, good, very good, excellent. The qualification of 'excellent' should only be given for a PhD Thesis in the top 3% of the research in your field of expertise.*
B. *E-mail the completed form to: Klara.Javorcekova@vut.cz*